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PAR 248

BPE High-Magnification Lens Set

7 August 1967

PROJECT AUTHORIZATION REQUEST

PAR 248

7 Aug 67

SUBJECT: BPE High-Magnification Lens Set

TASK/PROBLEM

1. Provide one high-magnification lens set (PAR 245) to increase the magnification range of a Briefing Print Enlarger (PAR 243S) at the customer's facility.

PROPOSAL

2. The contractor will fabricate one BPE High Magnification Lens Set to the design specifications outlined in PAR 245. This set, consisting of two objective/condenser assemblies (G and H) will be interchangeable with the six assemblies provided on the prototype Briefing Print Enlarger (BPE) and will extend the upper magnification range from 60X to approximately 155X.

3. The lens set will be checked out on the breadboard BPE (PAR 202/224) at the contractor's facility and will then be installed, adjusted, and checked out on the prototype BPE at the customer's facility.

SCHEDULE

4. The time span to complete above effort is estimated to be eight months after start of work. Test data will be delivered with the equipment in lieu of a Final Report. Status will be reported monthly in Quarterly or Monthly Reports.

997606

22 March 1968

Dear Ray:

We are forwarding herewith five (5) copies of the following report:

25X1 [redacted]

PAR 245 - Final Report (AL-18-700459-1 thru 5)

RRW:sjm

R. R. W.

Copy to: RS w/encs. (AL-18-700459-1 thru 5)
DW w/encs. (AL-18-700459-6)

#1 - 997606 (BPE Hi Mag Lenses)
#2 - 997244 (Prototype BPE)

25X1 #3 [redacted]

25X1 #4 #5 - 997164 [redacted]

This document contains
11 pages.

AL-18-700459-/
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PAR 245

FINAL REPORT

BPE High-Magnification Lens Sets

1 February 1968

25X1

Prepared by

[redacted]

Approved by

25X1

[redacted]

Date: 19 March 1968

[redacted]

25X1

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SUMMARY

It was desirable to extend the magnification range of the PAR 243A, Beacon Precision Enlarger* (BPE) beyond the original design goal of 60X to provide illustrations of a size suitable for group presentation. Experience indicated that two additional lens and condenser sets could span the range of 60X to 150X.

These assemblies had to be interchangeable with existing BPE lenses, and the same focus scheme had to be used. Relative apertures were selected by the designers to yield resolution capability at the print which would be adequate for eyeball viewing. The lenses were designed for printing on color-blind, blue-sensitive, print stock.

The results of optical and photographic tests of the lens sets indicate that the design requirements for these lenses were in all cases surpassed.

* Formerly called the Briefing Print Enlarger.

SUBJECT: BPE High-Magnification Lens Sets

TASK/PROBLEM

1. Design, fabricate, and test prototype optical systems to extend the [redacted] Precision Enlarger* (prototype), PAR 243A, upper limit magnification range from 60X to 140X - 160X.

25X1

INTRODUCTION

2. There was a need for extension of the magnification range of the Beacon Precision Enlarger beyond 60X to provide briefing illustrations for group presentation. For group viewing, image sharpness requirements in the print could be less stringent than for close-up viewing.

3. This project was authorized on 6 June 1966 and the completed lens sets were delivered to the customer on 1 December 1967.

DISCUSSION

4. A review of experience with the prototype BPE indicated that it was likely that its magnification range could be extended from 60X to about 150X by adding two more lenses and matching condenser sets. The first of these would cover the range from 60X to 97X; the second would cover the range from 95X to 150X. These lens and condenser assemblies would be interchangeable with the six lenses and condensers incorporated in the prototype BPE on PAR 243A.

5. These lenses were to be designed for printing on color-blind, blue-sensitive, print stock (such as Kodabromide Paper or Kodak Fine Grain Positive Film) or on blue-green-sensitive print stock (such as Polycontrast Paper).

6. The linear field coverage for these lenses had to be consistent with that of the existing BPE lenses which operate in the 9X to 60X magnification range. In other words, they must be capable of producing 20- x 24-inch prints working at a minimum overall conjugate distance of 50 inches. They therefore required about the same angular field coverage as the 40X to 60X lens, or a semifield angle of about 18°.

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* Formerly called the Briefing Print Enlarger.

7. The mounting arrangement for these lenses had to be identical in principle to the lenses developed for the prototype BPE on PAR 243A, and the glass negative gate had to be placed in the same position relative to the lamphouse gate glass. The same tensioned, focusing thread design and positive-driven digital counter for focus readout were also incorporated in the lens barrel assembly, and the mounting configuration was of course made interchangeable with existing lenses.

8. Condenser lenses had to be formulated to work with these new lenses in order to optimize exposure conditions from both elapsed-time and field-uniformity standpoints. In addition, the mountings for these condensers had to be interchangeable with existing hardware.

9. Focus Calibration and Performance:

a. Focus calibration was accomplished by determining the best focus setting at each of three overall conjugate distances. A photographic focus series was made at each position using a Wratten 98 blue filter and Kodak Fine Grain Positive Film print stock. The results were examined to determine which focus setting in each series yielded the best edge-sharpness in the image. This data, combined with other visual lens-bench measurements on each of the lenses, was used in a computer program to prepare the focus/magnification table. This focus/magnification table includes magnification and focus data for the original six lenses delivered with the BPE prototype under PAR 243A and was delivered and installed on the prototype enlarger at the customer's facility.

b. A series of test prints of the high-contrast resolution target was made for five easel positions (overall conjugate distances) for each lens, on axis, using the lens focus settings predicted by the computer run. These prints showed resolving power equal to that observed for the optimum focus position in the focus calibration measurements. Table 1 shows the measured field coverage of the six lenses and the observed axial resolving power (high contrast) for the sample lenses compared to the diffraction limit of resolving power (Rayleigh criterion) for the relative aperture of each lens and the wavelength of the light used.

Table 1

Performance of the BPE High-Magnification Lens with Blue Filter

Lens	Magnification Range Min	Max	Field Diameter at Negative (Inches)	Wratten 98 Observed Axial Resolving-Power High-Contrast (Cycles/mm)	Wratten 98 Diffraction Limit of Resolving-Power Rayleigh Criterion (Cycles/mm)
G	59.9X	97X	0.520	660	800
H	94.9X	153X	0.330	828	925

10. The focus assemblies for these lenses are almost identical to the one designed for the 40X to 60X lens (labeled "F") delivered with the prototype. The main externally discernible difference is the labeling. The 59.9X to 97X lens is labeled "G", and the 94.9X to 153X lens is labeled "H". There are some internal differences in fixed dimensions, which were necessary to accommodate the lenses of shorter focal length. Table 2 shows the range of focus adjustment required, the focus motion per count of the focus indicator, the lead of the focus barrel thread, and the focus barrel rotation required to cover the range of focus adjustment for each lens.

Table 2

Objective Lens Focus Mechanism

Lens Assembly	Nominal Lens EF (Inches)	Range of Focus Adjustment (Inches)	Focus Motion per Count (Inches)	Lead of Thread (Inches)	Range of Focus Barrel Rotation (Turns)
G	0.811	0.0052	0.00015625	0.03125	0.17
H	0.517	0.0021	0.00015625	0.03125	0.067

CONCLUSIONS

11. The High-Magnification Lens Sets which were fabricated, tested, and delivered to the customer's facility met design requirements.

12. A specification for the High-Magnification Lenses (see Appendix A) was developed, submitted to the customer, and approved by the customer's representative. The High-Magnification Lenses that were delivered under this PAR either met or surpassed the specification requirements.

13. The drawings which were prepared are suitable for manufacturing additional lens assemblies. These drawings are under document change control.

14. An Appendix will be added to the operational manual for the BPE which will include suitable information and instructions for using the High-Magnification Lenses.

RECOMMENDATIONS

15. Encourage users of the BPE to order these lenses wherever the additional magnification range is needed.

APPENDIX A

SPECIFICATION FOR HIGH-MAGNIFICATION LENSES
FOR BEACON PRECISION ENLARGER*

1. EQUIPMENT APPLICATION

These lenses are designed to extend the magnification range of the 25X1 [redacted] Precision Enlarger while retaining the ability to reproduce detail from high quality black-and-white aerial photographic negatives.

2. DESCRIPTION

2.1 The set of high-magnification lenses consists of two objective lens - focus barrel assemblies and their respective condenser-light source assemblies.

2.2 One objective-condenser combination provides magnifications in the range from 60X to 97X. The second objective-condenser combination provides magnifications in the range from 95X to 153X. These lenses are mounted in the same type of precision focusing assembly as the other BPE lenses.

2.3 The required focus setting for any desired magnification within the individual lens capability is displayed in the appropriate window of the Easel Drive Assembly. Provision is made in these lenses and their mating condenser assemblies to actuate related switches which will illuminate the correct focus data window when a lens-condenser set is installed in the enlarger. As with the other enlarger lenses, focus is set manually on these lenses.

2.4 Each condenser-light source assembly is equipped with its own 300 watt projection lamp. This lamp is identical to that used in all the other condenser assemblies for the enlarger.

3. PERFORMANCE

3.1 The nominal values of magnification (M), effective focal length (EFL), and relative aperture (f-number), are given in Table A-1 for the two lenses. The magnification achieved for a given negative-to-print distance (OAC) may

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* Formerly called the Briefing Print Enlarger.

vary ± 2% for various lenses of a production lot. The magnification value shown in the focus table may be in error by ± 1% from the true value.

3.2 The Minimum Axial Resolution specification of Table A-1 shall be applied to tests made as follows:

3.2.1. The test target material shall have at least 100:1 contrast, be in the USAF 1951 format. and provide 80 to 800 lines/mm. The material shall have been exposed on Kodak Type 649GH film on the Microscope Resolution Target Camera at the contractor's facility. The test target polarity will be clear lines in a high density background.

3.2.2. Test prints on the BPE are to be exposed on Kodak Fine Grain Positive Film (or on equal product) with a Wratten 98 (W98) blue filter in the lamphouse filter position.

3.2.3. Resolution performance will be judged as the highest spatial frequency in the test target whose image is visually resolved in the print. The criteria for judgment of image resolution shall be those of Paragraph 3.6.2. of MIL-STD-150A.

3.2.4. An exposure series may be exposed to obtain the optimum resolving power. The lens focus setting shall be that predicted by the focus table.

3.3 The off-axis resolving power shall be measured at the same focus and exposure which provided the axial resolution data and to the same criteria. The same type of test target material shall be used, preferably on a common piece of film. The arithmetic average of radial and tangential resolving power for four radii of the field of view, separated by 90° at a radial distance of 70% of the full field radius, shall be no less than 70% of the resolution measured on-axis.

3.4 The Minimum Field Diameter at the negative, as specified in Table A-1, is primarily controlled by the various aperture diameters in the condenser system. The field diameter at the print is determined by the field diameter at the negative and the magnification. The specified field diameter at the print shall be measured with the negative-to-print distance adjusted to produce the corresponding magnification given in the first column of Table A-1.

3.5 The log illuminance in the projected image of an open gate shall not decrease more than 0.30 below that on the axis at a point 0.8 of the maximum field radius from the axis.

Table A-1

High-Magnification Lens Specifications for Nominal Magnification, EFL, and f-number and for Minimum Axial Resolution and Field Diameter

Nominal Magnification		Lens		Minimum Axial Resolution		Minimum Field Diameter	
M (Diameter)	OAC (Inches)	EFL (Inches)	f-Number	Negative (l/mm)	Print (l/mm)	Negative (Inches)	Print (Inches)
60.0	50.				11		30.4
74.8	62.	0.81	f/2.6	650	9	.507	38.0
97.0	80.				7		49.1
95.0	50.				8		30.4
119.0	62.	0.52	f/2.2	740	6	.320	38.0
153.0	80.				5		49.0